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ABSTRACT

A quantitative synthesis (meta-analysis) was conducted on 49 studies of attitude toward the school subject of science. A conceptual framework for the study of attitudes toward science was introduced. The benefit of such a framework is that it accommodates the results of prior research as well as programmatic future efforts. The results of the synthesis revealed: (1) a lack of integrative quality to these studies; (2) improvement over the years in methodology; and (3) inadequacies in most research reports which inhibit the meaningful interpretations of the results. The research findings reveal: (1) there are small differences in attitudes for boys and girls; (2) sex interacts slightly with many variables but in no systematic way; (3) programs generally have a variable, positive effect on attitude; and (4) some learning environment and teacher variables have been found to be highly related to attitudes. (Author/DS)

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Attitudes Toward Science: A Quantitative Synthesis

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Abstract

A quantitative synthesis (meta-analysis) was conducted of 49 studies of attitudes toward the school subject of science. A conceptual framework for the study of attitudes toward science was introduced. The benefit of such a framework is that it accommodates the results of prior research as well as programmatic future efforts. The results of the synthesis revealed (a) a lack of integrative quality to these studies, (b) improvement over the years in methodology, and (c) inadequacies in most research reports which inhibit the meaningful interpretations of results.

Attitudes Toward Science: A Quantitative Synthesis

A review of the research on the correlates of attitudes toward science reveals a lack of integrative findings (Ramsay & Howe, 1969). A decade later, Peterson and Carlson (1979) reported similar findings stating: "Attitude research is chaotic...." (p. 500). Pearl (1973) lays much of the blame on inadequate instrumentation, while others have been concerned about the lack of a clear definition of attitudes toward science (e.g., Aiken & Aiken, 1969).

The present review has several purposes. First, research on correlates of attitudes toward science are reviewed with respect to sources of research, variables studies, and selected methodological issues. Scriven (1980) characterizes this kind of inquiry as "research on research." Second, the findings of 49 studies are examined in an effort to quantitatively integrate the results. Through such a synthesis of research findings, it is hoped that future research and development will be guided toward more productive efforts based on a better understanding of the dynamics of attitudes in instructional programs in science.

The outline of this paper is as follows. First, meta-analysis is described as a means for quantitatively analyzing the results of research. Second, attitudes toward science are discussed, and a definition provided. Third, a theoretical framework for the study of attitudes toward science is proposed. The framework provides a structure for the synthesis of studies. Fourth, procedures are described. Fifth, the results of the meta-analysis are presented and discussed. Finally, recommendations are offered, both for future efforts in research on attitudes toward science as well as for methodological issues in this research.

Meta-analysis

The term "meta-analysis" refers to the quantitative synthesis of research findings. Glass (1976) describes it thus:

> Meta-analysis refers to the analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings. (p. 3)

As Kulik, Kulik and Cohen (1979) point out, with over 100,000 scientific journals existing, researchers are unable to cope with the great number of research studies reported annually. If a researcher spent four hours a day speedreading 50 articles in that period, only 10% of the output in a field would have been assessed in a year. Faced with these realities, meta-analysis provides educators with incisive summaries of research findings.

While meta-analysis has a great many benefits, there are some limitations as well. First, research findings, as typically reported, vary greatly. Measures of attitudes and other variables may be poorly defined or unreliably measured. Such a state of affairs seriously distorts the results of any meta-analysis. Unreliable data is known to attenuate correlations, and relationships are consequently underestimated.

Second, any search for research on a topic will lead to the immediately identifiable, published studies, while conference reports, dissertations, and other unpublished papers are difficult to identify and obtain. As a consequence, only published or well cited studies may be included in the research synthesis. A bias is therefore introduced which is difficult to assess in terms of its effects on the results of a meta-analysis.

Third, some research reports are clearly not synthesizable. That is, the report fails to provide the basic, elemental descriptive statistics

that allow the reader to assess the significance of the results. Some recommendations for overcoming this problem are made in this review.

These problems should not belie the effectiveness of meta-analysis but merely point out some limitations. The results of meta-analysis should provide powerful insights into the study of determinants of attitudes toward science, but like any single research study, should be interpreted with some caution in light of these limitations.

Defining Attitudes Toward Science

A cursory review of the topic "attitudes toward science" will reveal that many persons define attitudes in a variety of ways. Peterson and Carlson (1979) report in their review that there are over 30 studies a year on attitudes toward science; however, a closer look reveals much diversity in definition. The problem of measuring attitudes, alluded to by Pearl (1973), begins to be solved by adequate definition. Fortunately, there has been extensive work on defining many aspects of science attitudes. These definitions are briefly presented here as a background for the present review, which focuses on the attitudes of students toward the subject matter of science.

Scientific attitudes. This term has connoted a student's approach to thinking about science. Guilford (1967) refers to this phenomenon as the "cognitive attitude" or a belief about thinking. A number of persons have done studies on scientific attitudes (Billeh & Zakhariades, 1975; Diederich, 1967; Moore & Sutman, 1970; Schwirian, 1968; Vitrogan, 1967; Welch & Pella, 1967, 1968). The instrument developed by Moore and Sutman (1970) is probably best known and most widely used as a measure of scientific attitudes. Diederich's definition is one of the most complex; he posits 20 specific

components of the scientific attitude. It is unclear how these studies coalesce to form a single concept about the scientific attitude. Research which interprets and integrates thinking about scientific attitudes is needed.

Attitude toward scientists. The study of this trait was motivated by the apparent decline in the number of students electing courses and, subsequently, careers in science. Studies have been conducted on this topic by Ahlgren and Walberg (1973), Fraser (1977, 1978), and Moore and Moore (1975). In general, students' perceptions about scientists seem well measured by a variety of instruments, but the work of Fraser (1977, 1978) is particularly outstanding because the instrument developed, the Test of Science-Related Attitudes, has a sound theoretical basis and an impressive empirical validation.

Attitudes toward a method of teaching science. Several persons have studied the attitudes of students toward specific instructional activities or methods (Babikian, 1971; Fraser, 1980). Fraser has identified four sources of information on science for the student which include experiment, expert, book, and teacher, and he also provides empirical data regarding the validity of these sources. Little other work has been done in this area, but Fraser's work appears promising in terms of shedding light on the problem of seeking specific causes of positive or negative attitudes toward science as a school subject.

Scientific interests. Earliest work in this area focused on interests in common with scientists, as measured by the Kuder Preference Record (Bingman, 1967; Wynn & Bledsoe, 1967). Walberg (1967) presents a theoretical framework, based on the work of Cooley and Reed (1961), and data supporting

the existence of five dimensions of scientific interests. More recent reports of research on scientific interests have not surfaced.

Attitudes toward parts of the curriculum. Several studies have focused on the student's perceptions of various activities or parts of the curriculum. For example, Perrodin (1966) surveyed activities, teacher behaviors, and subjects presented in a science class. Lazarowitz and Lazarowitz (1979) provide similar analyses. Sullivan (1979) conducted a survey that dealt with specific interests within general science, finding across-grade declines and considerable differential interests within a grade. The value of this kind of research is that it probes into the perceived interests in specific topics within a course of study, the implication being that teachers can plan more appropriately needed motivational strategies for low-interest yet essential topics. As Sullivan suggests, this research indicates a need for a series of studies, as more information is needed about the conditions surrounding these interests.

Attitudes toward the subject of science. While student achievement is the concern in most educational research, there has been a steady increase in interest in student attitudes as an important outcome of schooling. For this reason, a meta-analysis of research on attitudes toward the subject matter of science seems particularly salient at this time.

While there are a reasonable number of instruments measuring attitudes toward science for junior high school students and above, there are few well validated instruments that tap attitudes of students below grade seven. Neale, Gill and Tismer (1970) used a semantic differential with some success, and more recently, Haladyna and Thomas (1979a) used a self-report inventory to tap attitudes toward science in contrast to other subject matters. A

validation study of this instrument offered hope that science attitudes could be reliably measured in grades four through eight (Haladyna & Thomas, 1979b).

A conceptual framework is presented for the study of attitudes toward science. A framework posits the dimensions and the causal factors which may account for attitudes toward the subject matter of science.

A Model for Studying Attitudes Toward the Subject of Science

While there are many theories of school learning (Bloom, 1976; Bruner, 1966; Walberg, 1980), as well as theories of motivation (Eysenck, 1970), and theories of self-concept (Shavelson, Hubner, & Stanton, 1976), there is no parallel in the study of attitudes. Not even the affective taxonomy of Krathwohl, Bloom, and Masia (1964) provides a useful model for attitude studies, and no research has been encountered that attests to this taxonomy's effectiveness.

By model, we mean a framework that specifies the constructs, variables that we may subsume under each construct, and statements about the causal relatedness of these constructs.

A model such as the one described above can serve as a means for organizing the results of previous research in a meaningful way, as well as serve to guide researchers in future programmatic research.

The model, presented in outline here, is more completely described elsewhere (Olsen, Haladyna, & Shaughnessy, 1979). Three independent constructs are posited: teacher, student, and learning environment. Each of these constructs can be explicated more specifically in terms of classes of variables (see Haladyna, Shaughnessy, & Olsen, 1980, for a description of these variables).

The relationships among these three classes of variables can be simply expressed as: $Y = F[A, B, C]$

where Y represents the criterion measure, attitudes toward the subject matter of science,

A represents teacher variables,

B represents student variables, and

C represents learning environment variables.

While the expression is symbolic, it should imply to the reader that relationships are not simply linear, but may be complex, nonlinear and involve interactions.

All variables can be classified into one of two categories: exogenous and endogenous. Exogenous variables are those outside the immediate influence of the educational process, for example, age of student, sex of student, family background, cultural factors, and the like. Endogenous variables are those within the system that are under the control of the educational process and its agents, specifically, teachers, parents, and school administrators. For the most part, the model, illustrated in Figure 1, is young with respect to this idea of specifying the specific causes of attitudes. However, as we will see, research is not definitive in helping us identify these influences.

Insert Figure 1 about here

Teacher variables, such as age, sex, experience, professional involvement, teaching style, personality traits, and attitudes toward science, are seen as causally related to student attitudes. Learning environment variables are also viewed as related to these attitudes. It is the intent in this review to seek support for an emerging theory that supports the belief that the teacher is the primary change agent in affecting the learning environment, and that these two constructs, the teacher and the learning environment, work in concert to mainly affect attitudes.

Method

The first objective in this review was to identify all studies meeting certain sampling requirements and to subject each study to certain forms of quantitative analyses to determine the effect to which certain predictor variables have been studied, as well as to determine the strength of relationships between predictor variables and the criterion variable (attitudes toward the school subject matter of science). A second objective was to examine methodological strengths and weaknesses of these studies.

Sample and Population

The sampling constraints for this meta-analysis were as follows:

1. The search was limited to studies done in the United States. The reason for this decision was that the concern was on methods and conditions present in American education, assuming that instructional methods, environmental conditions, status of teachers and of students, vary from this country to other countries. Thus, the meta-analysis does not include many studies conducted in Great Britain, Israel, and Australia, which were reviewed by Gardner (1975) and Ormerod and Duckworth (1975).

2. Only elementary and secondary students' attitudes were considered. In this search, we chose not to include studies done on college students, preservice teachers (student teachers), and teachers.

3. The search was principally limited to studies reported between the years 1960 and 1980. Few studies exist before 1960, and most of these do not provide quantifiable results.

4. The review was concentrated on published reports. This decision was based on practical considerations and most directly affected the use of dissertations. Since only dissertation abstracts are published, these abstracted reports are used in the meta-analysis and not the actual dissertations. This is a compromise in the sampling of studies, but also a realistic constraint.

5. Studies reviewed were chiefly derived from several sources, including the Education Index, the Current Index to Journals in Education, Dissertation Abstracts, and the occasional reviews of research found in Science Education. In addition to these main sources, additional and ancillary sources include the fine review papers by Gardner (1975), Aiken and Aiken (1969), and a book by Ormerod and Duckworth (1975). References in all papers were checked for additional studies of relevance. These sources provided the studies that were included in this review.

Table 1 provides a description of these sources. It is interesting to note that three journals devoted mainly to science education research provide the bulk of the contributions to the review, and doctoral dissertations provide another large source. Reports of meetings, such as the annual meetings of the National Association of Research on Science Teaching or the American Educational Research Association were less fruitful, chiefly due

to the fact that these papers were unpublished and difficult to obtain. Programs seldom publish addresses of authors of conference papers. Also, many reports contain oblique references to the types of attitudes examined, thereby making identification more difficult.

Insert Table 1 about here

Table 2 provides a breakdown of studies by grade levels. As shown there, a balance exists in the number of studies conducted at each grade level.

Insert Table 2 about here

Table 3 provides a breakdown of studies conducted on attitudes toward specific courses of study. Of these 21 studies, 9 were done in the area of physics. Seven of these studies in physics were conducted by Walberg, Rothman, Welch, and Ahlgren as part of the programmatic research done on The Harvard Project Physics (reviewed by Welch, 1973).

Insert Table 3 about here

Procedures

All 49 studies meeting the sampling constraints were subjected to an analysis to determine the strength of association between any predictor variables and the criterion. As shown in Tables 2 and 3, a large number of studies did not have sufficient reports of results to perform a research synthesis.

In studies where the data were synthesizable, the variety of methods of data analysis made synthesis more difficult. The problem was that of equating correlational results with results where group differences were tested using analysis of variance, a t-test, or some multivariate procedure. The inconsistency in reporting descriptive statistics as well as other salient statistical data made the meta-analysis only more difficult.

This problem was resolved by using a least squares regression approach to data analysis. The relation between any predictor and the criterion can be reported with the percent of accounted variance of the test score of the criterion measure by the predictor measure. Three cases are briefly presented which provide the basis for this comparison.

Correlation. The squared product-moment correlation coefficient represents the percentage of criterion variance accounted by the predictor variable. If a correlation is .50, the squared correlation is .25 indicating that about 25% of the criterion variance is explained by the predictor. This extends to the multivariate case where the squared multiple correlation coefficient, R^2, provides the same metric, percent of accounted variance.

When an independent variable has two or more levels, the results can be treated in a least squares regression framework where the sums of squares between can be computed. The ratio of the sums of squares between and the sums of squares total is identical to the correlation ratio. This ratio is interpreted in the same manner as r^2 and R^2, the proportion of accounted variance

Results and Discussion

Of the 49 studies identified which dealt clearly with the dependent variable of student attitudes toward the subject matter of science, 19 had synthesizable results, 27 had non-synthesizable results, and 3 studies had

reports of data of each type. The preponderance of synthesizable reports (82%) were from published articles, emphasizing the importance of publication in a journal as a means for communicating research results. The main source of non-synthesizable studies was dissertation abstracts, which by their very nature do not contain complete or comprehensive accounts of research.

Preidctor Variables

The frequency with which certain predictor variables appeared in these 49 studies is given in Table 4. As shown there, sex differences and interactions with this variable have received the most study in the category of student variables. Grade level has frequently been studied. Unfortunately, this category can be subdivided as a function of the interval between times of testing. For example, some studies deal with how attitudes change over grade levels, while other studies deal with changes within the school year. Finally, two studies deal with the stability of attitudes over a very brief time span.

Insert Table 4 about here

There have been fewer instances of studies with predictor variables relating to the teacher, and these studies have been diffuse in their focus. Five studies have focused on student perceptions of teacher initiated activities as related to attitudes, while only four studies have looked at teacher personality characteristics. At least 14 major variables can be identified, with teacher personality actually representing a class of variables, for example, the scales of the California Personality Inventory.

In the area of learning environment, two classes of variables have received sole attention: (a) program effects, and (b) variables of the

Learning Environment Inventory (LEI). With the former, 22 of the 49 studies in this review contained some description of the utility of a program or of teaching procedures. In most cases the program was some innovative effort to change attitudes toward and/or achievement in science. In these instances, these studies can be construed as evaluation research which bears on the fruitfulness of a particular program of instruction or a set of teaching procedures.

Four studies in this synthesis utilize the LEI, and each of the 14 scales of the LEI, as predictors of a science interest measure.

Research Findings

Of all predictor variables involved in these 49 studies, only 18 appeared with a frequency of two or more (see Table 4). Most variables were observed in fewer than ten studies. Thus, it is difficult to provide a synthesis of findings for no more than a few variables. This portion of the synthesis will report the findings arising from the more frequently studied variables as well as highlights of particularly strong, yet infrequently observed, findings. As an introduction to these findings, the strength of association for all variables found in synthesizable reports is given in Table 5.

Insert Table 5 about here

The results shown in Table 5 indicate that most findings relating to student variables account for very little of the criterion variance. A small number of findings involved strengths of association over 15. This is equivalent to a correlation of .387. With teacher variables, again a slightly bimodal distribution is shown in Table 5. Most findings accounted

for less than 2% of the variance, but in four instances, the results accounted for 13% or more of the variance. With the learning environment, the most findings were reported with a multimodal distribution. More uniquely, the studies where higher effects were noted were performed on class means. These studies suggest that when the unit of analysis changes from the student to the class, attitudes are more predictable. This observation would suggest that a collectivity factor exists in attitude development that is classroom specific--which may be uniquely accounted by the teacher and the classroom learning environment.

These findings classified by the categories of student, teacher, and learning environment will be discussed in greater detail.

Sex differences and interactions with sex differences. The greatest proportion of studies (35%) involved the study of boy-girl differences and the interaction of this variable with another variable, e.g., program, grade level.

Of these studies where boy-girl differences were involved, the synthesizable data yielded coefficients ranging from 0 to 12.8% with a median of 3.2%. The median value is equivalent to a correlation of .18, thus indicating that there is a slight relationship between sex of student and attitudes toward science. While boys were found to like science more than girls like science, this difference is consistently small and variable from study to study and from grade to grade. The results of non-synthesizable studies indicate a similar pattern; one study shows a strong relationship, five show statistically significant relationships, and four show no relationships.

Interactions with sex differences are very diffuse in their patterns. Two studies report non-significant interactions with variables, while several

studies report some patterns across grades which are not replicated by other similar studies. These studies seem to show some promise for the interaction of sex differences with other variables, but there has not been any systematic study of these interactions.

Program differences. Of the 22 studies dealing with program differences or program effectiveness, the results of these reveal a widely ranging pattern of results. Most programs, by virtue of their design, will positively change cognitive and affective components which they were designed to affect. What is surprising about these results are the many weak findings, particularly three studies dealing with the SCIS program in the primary grades, where effect coefficients were 2.6%, 4.5%, and 5.4%, respectively. Several studies reported coefficients as high as 27.1% and 19.8% for fifth and sixth grade classes, both dealing with conventional and non-conventional methods of teaching as opposed to the study of a specific program. Another study deals with the treatment of low achieving students with different methods, and, again, strong effects were reported, 11.1%, 16.9%, and 17.3%.

Infrequent, strong relationships. In the previous sections, we have sought to characterize the correlates of science attitudes in terms of the most frequently studied variables and the patterns or lack of patterns in these findings. In this section we draw attention to findings that appear particularly promising for future inquiry. These findings are those that include variables that appear less frequently but the strengths of association were uniquely high, roughly equivalent to correlations at .35 and higher. Generally, these results follow the three major classes of variables introduced earlier: the student, the teacher, and the learning environment.

Among student variables, the relation of attitude to achievement has been consistently of a low order of relationship, with an occasional finding

that exceed 10.0%. The range of these findings for synthesizable results is from .01% to 12.2%, with the median being 2.4%, which is equivalent to a correlation of .15. Thus, there is no strong relationship between the two variables but a consistently low and positive one, which is similar to those findings reported in mathematics by Aiken (1976). One study (Reed, 1961) reports fathers' interests as highly related to attitudes, while another study found teachers' use of intrinsic motivation to be highly related to attitudes.

For teacher variables there are no reports of extensive studies of any single variable. However, among the more promising variables are the activities initiated by the teacher, which typically account for small positive correlations with attitudes. One study, using interviews, provided much anecdotal information regarding teacher personality and characteristics as related to attitudes. While the study is non-empirical, it points to the potential of teacher characteristics as a predictor of student attitudes. Some studies dealing specifically with teacher personality characteristics also indicate a strong relationship to student attitudes, particularly dominance and aggression, where these two characteristics were highly related to attitudes. Finally, the use of intrinsic motivation by teachers was found to be related to student attitudes; the magnitudes of these relationships were reasonably high, 16.9% and 17.6%.

The findings reported here are either single incidents or less frequent than other findings, yet these results point to the promise of these variables as potentially good predictors of attitudes toward science.

Several learning environment scales have been found to be highly related to attitudes, including satisfaction, speed, apathy, favoritism, goal direction, disorganization. In four studies, multiple correlation yielded effect

coefficients ranging from 16.8% to 75%. These studies reveal the potency for learning environment variables as predictors of attitudes toward science.

Conclusions

This section will be devoted to a discussion which is centered around three concerns: (a) findings, (b) methodological concerns, and (c) quality of research reports.

Findings

The results of this meta-analysis have clearly revealed the accuracy of earlier reviews, that research on attitudes is somewhat disorganized and chaotic. Clearly, research on attitudes is diffuse in focus as well as emphasis. Balance among studies with respect to grade level studied is relatively good; however, few studies span more than one grade. It seems reasonable and important to include several grade levels in any study of attitudes to determine if trends exist across grades. The interaction of sex difference and other variables seems useful in this context.

With studies in the secondary school, only one study included three courses, biology, chemistry, and physics. Other than this exception, most studies focus on one of these three science courses or on general science. As a result, little is known about any of these, with the major exception being physics which was extensively researched almost a decade ago. These accrued studies remain among the best in terms of focus, emphasis and breadth of coverage of variables across the categories of teachers, students, and learning environment. Unfortunately, they are not enough. It is surprising that these studies have not served as models for replication at other grade levels in other science courses and in general science.

The emphasis on variables in these 49 studies reveals a strong tendency to choose variables in a haphazard way without regard for the theoretical significance of any choice. Given that certain variables (endogenous) are subject to modification or experimental manipulation, the use of exogenous variables, such as sex, are mainly useful as control variables in experimental studies. Since we cannot change or modify exogenous variables, it seems prudent to research teacher and learning environment variables in an effort to better understand how these two categories of variables may be influenced in an effort to increase attitudes through classroom interactions.

The essence of these research findings reveals that (a) there are small differences in attitudes for boys and girls, (b) sex interacts slightly with many variables but in no systematic way, (c) programs generally have a variable, positive effect on attitudes, and (d) some learning environment and teacher variables have been found to be highly related to attitudes. However, the evidence is not yet conclusive as to which of these teacher and learning environment variables are most predictive.

Methodological Concerns

Since this review includes articles published between the years 1960 and 1980, it seems appropriate to note the growth in quality of methodology, and encourage this trend. Studies published in the more recent decade are better designed, research questions more clearly stated, samples better described, and instruments more completely described and validated. The most significant change has been in statistical analysis. Virtually all earlier studies involved simple comparison of group differences which involve analysis of variance or t-tests, while the balance of these early studies involved correlations. A few of these earlier studies employed techniques which

involve tabulation instead of statistical analysis. Recent studies have used regression analysis and other multivariate techniques with much success. Certainly, researchers are encouraged to continue to use these multivariate techniques when they are appropriate. While it can be argued that such results are difficult to communicate, the results of such analyses provide more substantial findings than we realize with univariate analyses.

Quality of Research Reports

The fact that 27 of 49 or 55% of the reports were non-synthesizable is indicative of the poor quality of many research reports. Given that any report should communicate the nature of the study and its significance to science education to a wide audience of science educators, it seems that at a minimum a report ought to include the following:

1. A theoretical rationale, stating why the study was conducted, what is believed, hypothesized and why, and what significance the study has for science educators.
2. Some indications of the research questions to be answered.
3. A description of the sample, including the numbers of boys and girls and grade levels studied.
4. A description of instrumentation including reliability estimates and evidence of validity. Instruments ought to be footnoted as to where they may be obtained. ERIC may be used to deposit such instruments for ease of acquisition.
5. The method of analysis ought to include multivariate procedures where appropriate. In descriptive studies, simple product moment correlations should be computed and other procedures, such as canonical correlation, multiple regression, path analysis or

other multivariate procedures should be attempted to associate classes or groups of variables with the criterion or criteria.

6. All data should be presented in a format that communicates the essence of the findings as well as the magnitudes of the effects. With correlation, coefficients should be presented. With multiple correlations, the unique and combined effects of variables should be listed. In studies involving group differences, means and standard deviations seem very desirable, particularly in assessing effect sizes of results.

There has been limited progress in understanding the determinants of science attitudes through previous research. Programmatic research is needed which operates in the context of a conceptual framework and provides findings that are translatable to teachers in terms of modifying classroom practices and learning environments.

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Footnotes

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Table 1

Sources of Studies

1.	Journal of Research in Science Teaching	6
2.	Science Education	5
3.	School Science and Mathematics	7
4.	Other Refereed Journals	10
5.	Dissertation Abstracts	16
6.	Conference Reports	4
7.	Other	1
	Total	49

Table 2

Breakdown of Grade Levels Studied

(N = 49)

Grade Levels Studied	Synthesizable Results	Non-Synthesizable Results	Total[1]
1	0	0	0
2	3	2	5
3	2	2	4
4	3	7	10
5	4	6	10
6	6	11	17
7	5	8	13
8	3	8	11
9	3	5	8
10	8	7	15
11	6	10	16
12	6	10	16

[1] The total exceeds 49 due to the fact that several studies spanned more than one grade level.

Table 3

Specific Subject Matter Emphases

for High School Studies

(N = 24)

	Synthesizable Results	Non-Synthesizable Results	Total
General Science	3	5	8
Biology	0	3	3
Chemistry	1	4	5
Earth Science	1	0	1
Physics	6	3	9
Totals	11	13[1]	

[1] In one study attitudes were surveyed across the specific courses of biology, chemistry, and physics.

Table 4

Frequency[1] with Which Predictor Variables Appear in Studies

(N = 49)

Student	Synthesizable Results	Non-Synthesizable Results	Total
Sex Difference	6	11	17
Interactions with Sex	4	5	9
IQ	2	4	6
Achievement	3	4	7
Grade Level (Time)	6	8	14
Grades	2	2	4
Academic Plan	1	2	3
Importance of Science	1	3	4
Usefulness of Science	1	2	3
Family Background	0	3	3
Socio-Economic Status	1	4	5
Teacher			
Activities	2	3	5
Personality	2	2	4
Class	1	1	2
Quality	1	1	2
Effort	1	1	2
Learning Environment			
Program	9	13	22
LEI	3	1	4

[1] All variables with a frequency of "1" are omitted.

Table 5

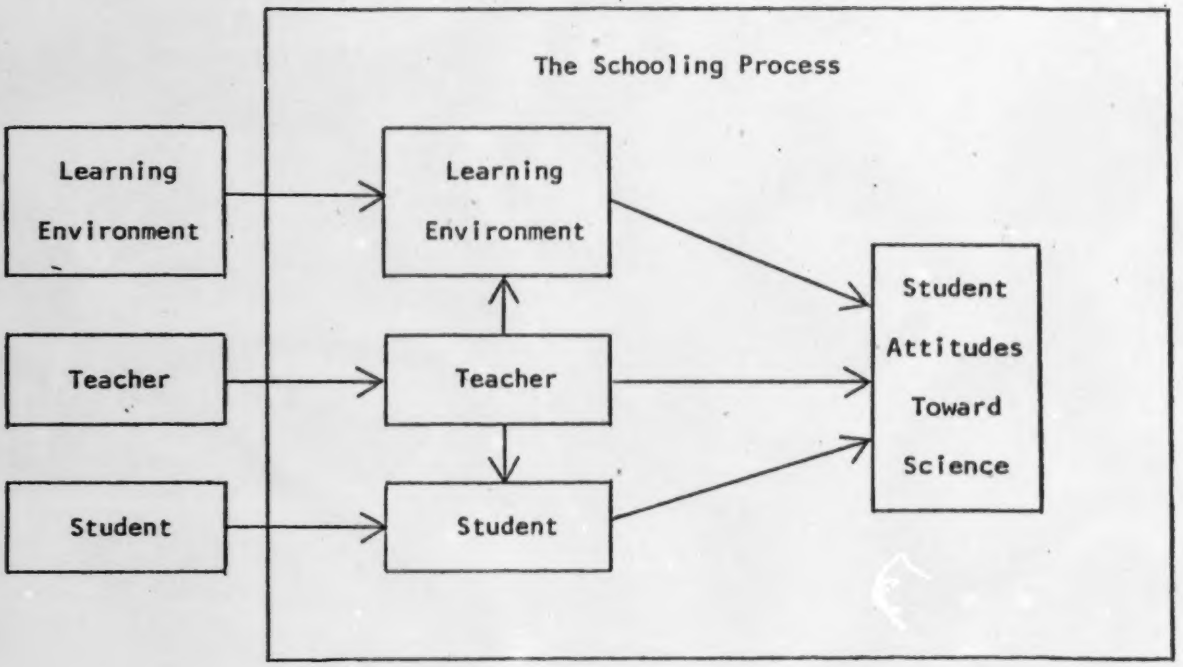
Strength of Association Between Predictor Variables and Attitudes Toward the Subject Matter of Science Across Three Dimensions of Schooling

Strengths of Association (Percentages)	Student	Teacher	Learning Environment	Strengths of Association (Percentages)
25.0+	XXX		XXX	25.0+
20.0	XX	X	XX	20.0
15.0	XXX	X	XXXXX	15.0
14.0		X	X	14.0
13.0	X	X	XXX	13.0
12.0	XXX			12.0
11.0	X		XXX	11.0
10.0	X	X	X	10.0
09.5			X	09.5
09.0	X			09.0

08.5	X		XX	08.5
08.0	X			08.0
07.5		XX	X	07.5
07.0			XXX	07.0
06.5			X	06.5
06.0			XXX	06.0
05.5			XXXXXX	05.5
05.0	XXXX		X	05.0
04.5	XX		XXX	04.5
04.0	XX		XXX	04.0
03.5			XX	03.5
03.0	X		XX	03.0
02.5			XX	02.5
02.0	XXX		XX	02.0
01.5	XXX	X	XX	01.5
01.0	XXXXXX	X	XXXX	01.0
00.5	XXXXXXXXXX	XXXX	XXXXXXXX	00.5
00.0	XXXXXXXXXXXXXXX	XXXXXXXXX	XXXXXXXX	00.0
	XXXXXXXXXXXXX			

Figure Caption

Figure 1. Illustration of the roles of exogenous and endogenous variables on attitudes toward science.


The Schooling Process
Learning Environment
Teacher
Student
Learning Environment
Teacher
Student
Student Attitudes Toward Science